Simulation: Half-Life Investigation

FOR THE TEACHER

Summary
In this simulation, students will have the opportunity to investigate the decay of two samples of unstable atoms. Students will interact with the simulation in order to decay the unstable samples resulting in a visual and graphical interpretation of half-life.

Grade Level
High school

NGSS Alignment
This simulation will help prepare your students to meet the performance expectations in the following standards:

- **HS-PS1-8**: Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
- **Science & Engineering Practices**:
  - Using Mathematics and Computational Thinking
  - Analyzing and Interpreting Data

AP Chemistry Curriculum Framework
This activity supports the following unit, topic and learning objective:

- **Unit 5: Kinetics**
  - **Topic 5.3**: Concentration Changes Over Time
    - **TRA-3.C**: Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.

Objectives
By the end of this simulation, students should be able to

- Indicate what happens to a sample size when it undergoes as half-life decay.
- Identify that radiation is emitted during the decay process.
- Determine the approximate sample size that will remain based on the length of a half-life for a given sample.
- Identify the shape of the graph produced during exponential decay.
- Define the meaning of “half-life.”

Chemistry Topics
This simulation supports students’ understanding of

- Nuclear Chemistry
- Half-life decay
- Radioactive Isotopes
- Radiation

Time
**Teacher Preparation**: minimal
**Lesson**: 30-45 minutes

Materials
- Computer, tablet or phone with internet access

Thanks to
The Camille & Henry Dreyfus Foundation
- Student Activity handout

**Safety**
- No specific safety precautions need to be observed for this activity.

**Teacher Notes**
- This simulation could be used in a teacher-lead lecture, or it could be used as a student activity.
- The number of particles available for selection in this simulation varies between 500 and 1000, and is used to show students a general example of how radioactive decay occurs. It is not meant to imply that a sample of this size could be visualized or quantified.
- It is recommended that students should be exposed to the concept of radioactivity and radioactive decay prior to using this simulation.
- In this simulation “Element X” and “Element Y” are not intended to represent a specific element from the periodic table. Instead, they are used with the intention of demonstrating the process of half-life decay. Students will determine that “Element X” must undergo 4 half-lives in order to reach stability, while “Element Y” must undergo 6 half-lives in order to reach stability.
- Please note that specific types of radioactive decay, such as alpha and beta decay are not discussed in this simulation.
- The simulation can be found at either of the following links:
  - [teachchemistry.org/half-life](http://teachchemistry.org/half-life)

**FOR THE STUDENT**
**Lesson**

**Simulation: Half-Life Investigation**

**Background**
In this investigation you will investigate the radioactive decay of two element samples. Through your investigation you will be able to determine the number of half-lives that each element must undergo in order to reach stability. You will be asked to answer questions as you navigate through the steps of the simulation. You can find the simulation here: [teachchemistry.org/half-life](http://teachchemistry.org/half-life)
Investigate
1. Choose “Element X” to begin. Using the slider, choose a sample size. Record your initial sample size below:

2. Select “Decay Sample.” Describe what happens to the sample size. What else occurs during the decay process?

3. Continue to decay the sample until you arrive at stability. How many half-lives occurred in order for the sample to reach stability?

4. If you started over with a larger sample size of Element X would you expect it to decay differently than this sample? (Ex: would it take more, less, or the same number of half-lives to reach stability?)

5. Start over. Select a sample size of 812 particles, again for Element X. Complete the following table, predicting the outcome before using the simulation (omit any rows that are not necessary in the table).

<table>
<thead>
<tr>
<th>Element X</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>812</td>
</tr>
<tr>
<td>1st Half-life</td>
<td></td>
</tr>
<tr>
<td>2nd Half-life</td>
<td></td>
</tr>
<tr>
<td>3rd Half-life</td>
<td></td>
</tr>
<tr>
<td>4th Half-life</td>
<td></td>
</tr>
<tr>
<td>5th Half-life</td>
<td></td>
</tr>
<tr>
<td>6th Half-Life</td>
<td></td>
</tr>
</tbody>
</table>

6. Use the simulation to verify your results for question 5.

7. Start over. Now select “Element Y.” Choose a sample size. Record your initial sample size below:

8. What do you expect to see happen when you click “decay sample”?

9. Decay the sample of Element Y until it reaches stability. What did you notice about the decay of Element Y that was different than Element X?

10. Consider the graphs created during the radioactive decay process of both Element X and Element Y. How were they the same? How were they different?

Applying what you learned
1. In your own words define “half-life.”

2. In your own words describe the meaning of “radioactive isotope.”
3. Iodine-131 is a radioactive isotope, and is often used in certain medical treatments. It has a short half-life of about 8 days. If a hospital has a 750mg sample of it available, how much would be available after 48 days?

4. Manganese-58 has a half-life of about 3 seconds. If you have a 90.0 gram sample, how long would you expect it to take to decay to approximately 1.40 grams?

5. A 100.0 gram sample of Polonium-210 is contained for 552 days. How many half-lives occur during this period of time, if the half-life is 138 days?

Extension
Research the following terms: alpha decay, beta decay and gamma decay
Briefly explain the meaning of each below: